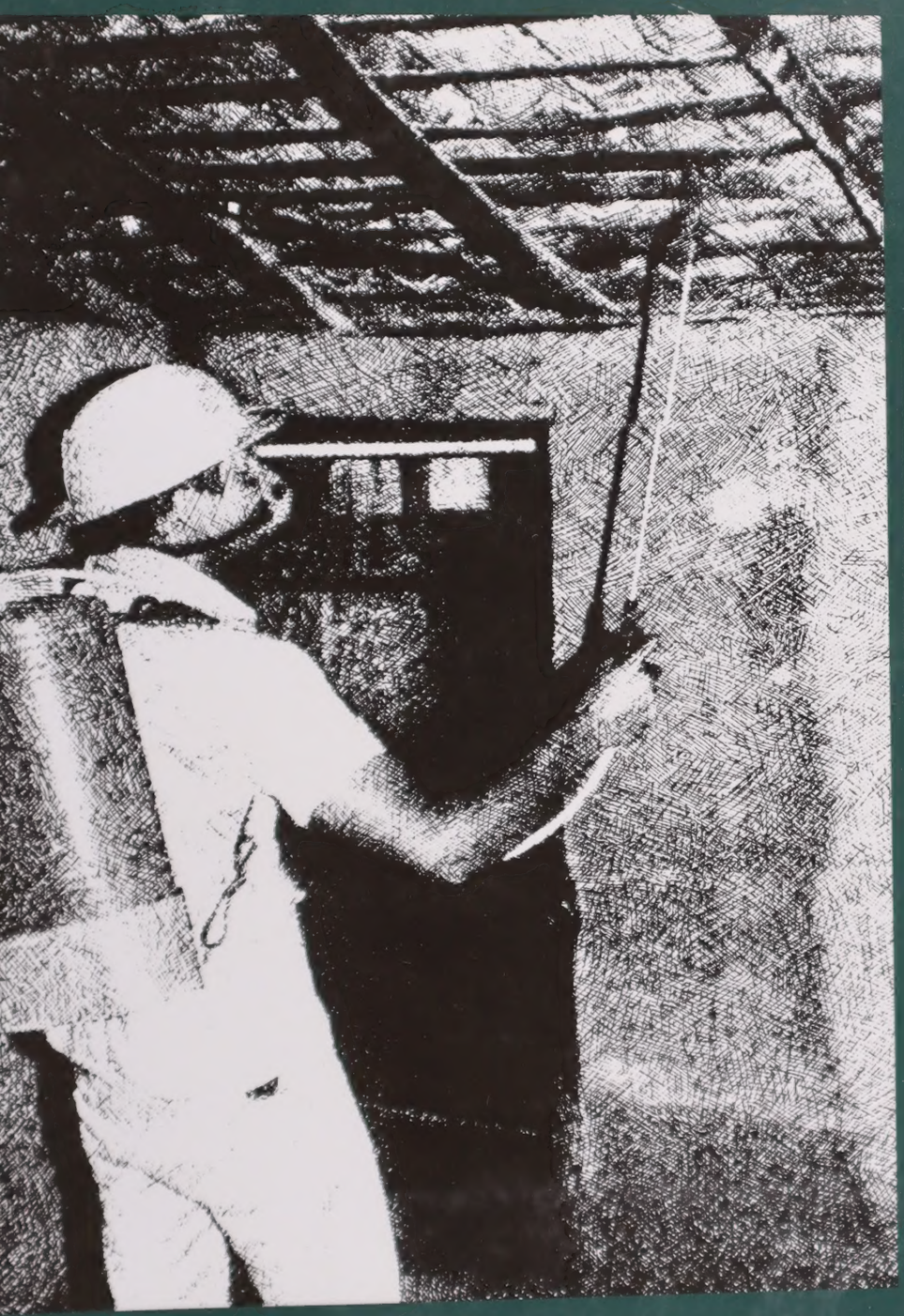
# icon

## PUBLIC HEALTH INSECTICIDE



# TECHNICAL PROFILE

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PUBLIC HEALTH INSECTICIDE

# Contents


| chapter | | page no. |
|---|---|---|
| 1 | **Summary** (English; Arabic; French; Portuguese; Spanish) | 2 |
| 2 | **Abbreviations** | 3 |
| 3 | **Introduction** | 4 |
| 4 | **Mosquitoes** | 5 |
| 4.1 | **Laboratory studies** | 5 |
| 4.1.1 | Intrinsic activity | 5 |
| 4.1.2 | Residual activity | 5 |
| 4.1.3 | Larvicidal activity | 7 |
| 4.2 | **Field evaluation** | 7 |
| 4.2.1 | Residual control of *Anopheline* mosquitoes | 7 |
| 4.2.2 | Effect on malaria transmission: Wall sprays/Bednets | 8 |
| 4.2.3 | Space treatment: Thermal Fog/Cold Aerosol (ULV) | 9 |
| 5 | **House Flies** | 11 |
| 5.1 | **Laboratory studies** | 11 |
| 5.1.1 | Intrinsic activity | 11 |
| 5.1.2 | Space treatment | 12 |
| 5.1.3 | Residual activity | 12 |
| 5.2 | **Field evaluation** | 13 |
| 5.2.1 | Space treatment | 13 |
| 5.2.2 | Residual control | 13 |
| 6 | **Cockroaches** | 14 |
| 6.1 | **Laboratory studies** | 14 |
| 6.1.1 | Intrinsic activity | 14 |
| 6.1.2 | Flushing effect | 14 |
| 6.1.3 | Knockdown | 15 |
| 6.1.4 | Residual activity on various substrates | 15 |
| 6.2 | **Field evaluation** | 17 |
| 7 | **Reduviid Bugs** | 18 |
| 7.1 | Laboratory studies | 18 |
| 7.2 | Field Evaluation | 18 |
| 8 | **Tsetse Flies** | 19 |
| 8.1 | Laboratory studies | 19 |
| 8.2 | Field Evaluation | 19 |
| 9 | **Other Pest Species** | 20 |
| 9.1 | Fleas | 20 |
| 9.2 | Scorpions | 20 |
| 9.3 | Crickets | 21 |
| 9.4 | Spiders | 21 |
| 9.5 | Other species | 21 |
| 10 | **Toxicology** | 22 |
| 10.1 | **Laboratory studies** | 22 |
| 10.2 | **Field experience/Safety evaluation** | 22 |
| 11 | **Environmental Studies** | 24 |
| 12 | **Chemical and Physical Properties** | 25 |
| 13 | **Formulations and Standard Recommended Rates of Application** | 26 |
| 14 | **References** | 28 |

# Summary


**Summary**

- Novel pyrethroid insecticide
- Based on lambda-cyhalothrin
- Exceptionally high activity
- Broad spectrum
- Long residual activity on inert surfaces
- No smell or staining
- Photostable
- Low environmental impact
- Variety of formulations available
- Discovered by Zeneca



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**Résumé**

- Insecticide pyréthrinoïde original
- A base de lambdacyhalothrine
- Exceptionnellement actif
- Spectre large
- Activité résiduelle de longue durée sur les surfaces inertes
- Ni odeur ni taches
- Photostable
- Faible impact sur l'environnement
- Diverses formulations disponibles
- Découverte par Zeneca



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**Resumen**

- Novedoso insecticida piretroide
- Con base de lambdacihalotrina
- Excepcionalmente activo
- Espectro amplio
- Actividad residual de larga duración en las superficies inertes
- No huele ni mancha
- Fotoestable
- Poco impacto sobre el medio ambiente
- Disponible en varias formulaciones
- Descubierto por Zeneca



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**Resumo**

- Novo insecticida piretróide
- A base de lambdacihalotrina
- Excepcional alta atividade
- Amplo espectro
- Longa atividade residual sobre superfícies inertes
- Não tem cheiro e não mancha
- Fotoestável
- Baixo impacto no meio ambiente
- Variedade de formulações disponíveis
- Descoberto pela Zeneca



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**الخلاصة**

- مبيد بيروثرويدي جديد للحشرات وآفات الصحة العامة
- قائم على المادة الفعالة من الجيل الثالث لامبدا ـ سايهالوثرين
- فعّالية عالية بدرجة إستثنائية
- واسع الاستعمال ضد مجموعة واسعة من الحشرات
- فعّالية يدوم تأثيرها مدة طويلة على السطوح الخاملة
- بدون رائحة أو تبقّع
- مركب ثابت لا يتأثر بالضوء
- تأثير منخفض في البيئة
- أنواع مختلفة من التشكيلات لمختلف الإستخدامات
- إكتشفته زنيكا ليمتد، إنكلترا.



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# Abbreviations

2

| | | |
|---|---|---|
| ai | : | active ingredient |
| cm | : | centimetre |
| CS | : | capsule suspension (microcapsule) |
| DAT | : | days after treatment |
| EC | : | emulsifiable concentrate |
| g | : | gram |
| ha | : | hectare |
| hr | : | hour |
| KD | : | knockdown |
| kg | : | kilogram |
| l | : | litre |
| LC | : | lethal concentration |
| LD | : | lethal dose |
| LSHTM | : | London School of Hygiene and Tropical Medicine |
| m | : | metre |
| mg | : | milligram ($10^{-3}$ g) |
| ml | : | millilitre ($10^{-3}$ L) |
| mins | : | minutes |
| ng | : | nanogram ($10^{-9}$ g) |
| nl | : | nanolitre ($10^{-9}$ L) |
| ODNRI | : | Overseas Development and Natural Resources Institute |
| PBO | : | piperonyl butoxide |
| ppm | : | parts per million |
| SUCAM | : | Superintendencia de Campanhas de Saúde Pública, Brazil |
| TDRI | : | Tropical Development Research Institute |
| µg | : | microgram ($10^{-6}$ g) |
| ULV | : | ultra low volume |
| USDA | : | United States Department of Agriculture |
| WAT | : | weeks after treatment |
| WHO | : | World Health Organisation |
| WP | : | wettable powder |
| w/v | : | weight/volume |
| w/w | : | weight/weight |

# 3 Introduction

Insecticides are a vital element in the control of the insect vectors that transmit diseases such as malaria, yellow fever, dengue, filariasis, the trypanosomiases (sleeping sickness and Chagas' Disease) and the leishmaniases. In many cases the use of insecticides may be the only practicable method of control. Insecticides are important too in combating noxious nuisance pests, such as cockroaches, houseflies, fleas and bed bugs, which reduce the quality of our lives and can transmit diseases such as dysentery and plague.

Special characteristics are required of an insecticide if it is to be used for any one such public health purpose. To claim that a single insecticide can be suitable for the full spectrum of public health insect control is quite exceptional. We make that claim for 'Icon'!

'Icon' is a quite exceptional insecticide. Invented and developed in the company's laboratories, it contains the novel pyrethroid lambda-cyhalothrin. The intrinsic activity of 'Icon' is among the very highest of any insecticide ever commercialised. Its breadth of target spectrum is second to none. 'Icon' is available in a wide range of formulations suitable for almost any method of application: space treatment, residual spraying, aerial application, fabric impregnation, soil drenching or treatment of wet areas.

'Icon' is fast acting, yet long lasting. 'Icon' persists as a residual deposit on inert surfaces such as walls, yet breaks down rapidly and harmlessly in the natural environment. 'Icon' is extraordinarily toxic to insects yet, when used as directed, poses no threat to non-target organisms such as mammals, birds or reptiles. 'Icon' may be used indoors and out, in domestic or commercial premises, and spraymen need take only normal safety precautions. 'Icon' is easy to store, easy to carry, easy to mix and easy to use.

This booklet describes some of the many trials that have been conducted worldwide, in the laboratory and in the field, to evaluate 'Icon's' exceptional properties in collaboration with the World Health Organisation and independent institutions.

'Icon', coded OMS3021 by WHO, has now successfully completed the evaluation scheme (WHOPES: World Health Organisation Pesticide Evaluation Scheme). 'Icon' is fully endorsed by the WHO Division of Control of Tropical Diseases for the control of mosquitoes and the diseases they vector. WHO specifications have been issued (VBC/IS/91.23) for use as a standard for procurement (WHO,1991).

But trials are often artificial, and can only give an indication of the exceptional efficacy of 'Icon'. The real proof may be seen from the use of 'Icon' in a growing number of countries for the successful and routine control of many kinds of public health pests. 'Icon' is already recognised as a leader in the field.

# Mosquitoes

4

## 4.1 Laboratory studies

### 4.1.1 INTRINSIC ACTIVITY

'Icon' is one of the most active of all insecticides against mosquitoes. This is demonstrated by the ratio of rates of various insecticides which control adult females of a susceptible strain of *Aedes aegypti* by direct topical application in the laboratory (Fig. 1).

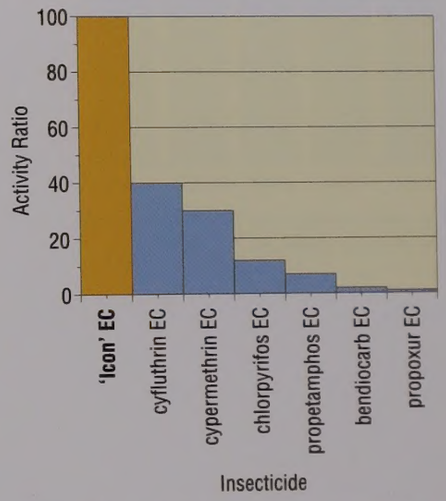
Two Collaborating Centres for the World Health Organisation (WHO) have reported the intrinsic activity of 'Icon' against mosquitoes:

**(1)** The Tropical Development and Research Institute (TDRI), UK showed that the lethal dose ($LD_{50}$) of 'Icon' applied to the thorax of female *Anopheles stephensi* was as low as 0.046ng ai/insect (TDRI,1985).

**(2)** The USDA Insects Affecting Man and Animals Research Laboratory demonstrated the very low concentration of 'Icon' that will kill mosquitoes when applied as a space spray to *Aedes taeniorhynchus*: $LD_{50}$0.4ppm and $LD_{90}$3ppm (USDA,1985).

The activity of 'Icon' against a range of mosquito species has been determined using the standard WHO filter paper susceptibility test (Fig. 2).

**Fig. 1. Comparative intrinsic activity (UK)***




** kill of Aedes aegypti (females, susceptible strain) by direct spray.*

### 4.1.2 RESIDUAL ACTIVITY

In laboratory experiments, 'Icon' has shown excellent residual activity on a wide variety of substrates.

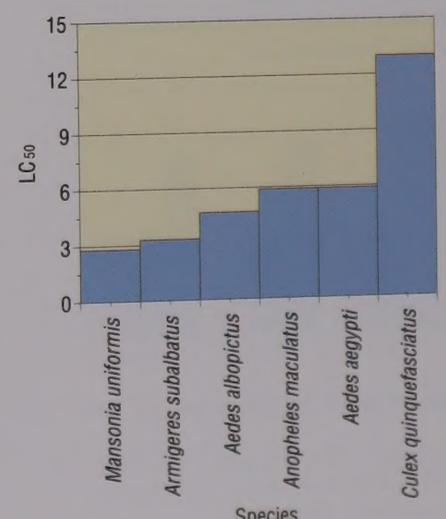
The persistence of 'Icon' and various other insecticides on plywood has been compared using an *Aedes aegypti* bio-assay at intervals up to 50 weeks. A rate of 'Icon' as low as 2.5 mg ai/$m^2$ showed no loss of activity during the trial. It was equal to or better than deltamethrin at the same rate and cyfluthrin at twice the rate (5 mg ai/$m^2$).

**Plywood (UK)**
**Residual activity on plywood* (UK)**

| Insecticide | Rate (mg ai/$m^2$) | Weeks after application | | | |
|---|---|---|---|---|---|
| | | 8 | 24 | 40 | 50 |
| 'Icon' EC | 2.5 | 100 | 100 | 97 | 100 |
| 'Icon' EC | 5.0 | 100 | 100 | 100 | 100 |
| bendiocarb WP | 100.0 | 100 | 67 | 93 | 98 |
| propoxur WP | 440.0 | 17 | 0 | 0 | 0 |
| cyfluthrin EC | 5.0 | 100 | 100 | 70 | 99 |
| cyfluthrin EC | 10 | 100 | 100 | 100 | 100 |
| cypermethrin EC | 20 | 100 | 100 | 100 | 100 |
| deltamethrin EC | 2.5 | 100 | 100 | 83 | 98 |
| deltamethrin EC | 5.0 | 100 | 100 | 100 | 73 |

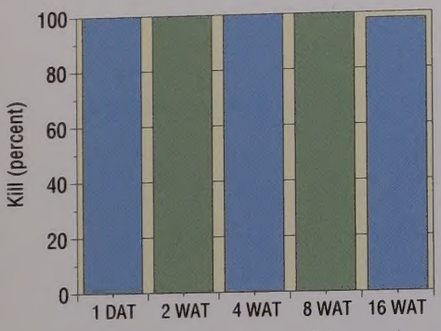
* kill (percent) of *Aedes aegypti* exposed for one hour, 24 hours after exposure.

**Fig. 2. 'Icon' WHO susceptibility test (Malaysia)***



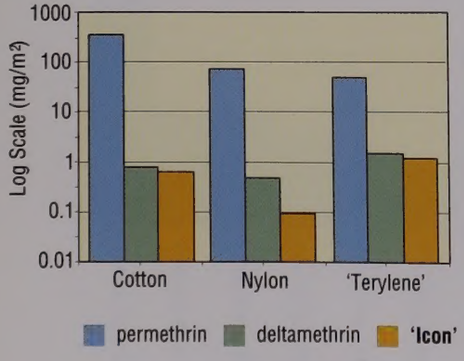

** lethal concentration (mg ai/$m^2$) to 50% of female mosquitoes exposed to 'Icon' exposed for one hour on filter paper.*

**Fig. 3. Residual activity of 'Icon' WP on unglazed porous tiles (UK)***




** kill % Aedes aegypti exposed for one hour, at 24 hours after exposure.*

**Fig. 4. $LC_{50}$ values of 'Icon', deltamethrin and permethrin on cotton, nylon and 'Terylene'(UK)***




** lethal concentration (mg ai/m²) to 50% of Anopheles gambiae exposed for 3 minutes to pyrethroid-treated netting.*

**Plywood (Malaysia)**

In an experiment in Malaysia, 'Icon' was superior to deltamethrin for residual control of mosquitoes and showed at least four times the activity of cypermethrin.

**Residual activity of 'Icon' and other pyrethroids on plywood against *Aedes aegypti* (Malaysia)***

| Insecticide | Rate (mg ai/m²) | Weeks after application | | | |
|---|---|---|---|---|---|
| | | 8 | 24 | 40 | 50 |
| 'Icon' EC | 2.5 | 100 | 100 | 97 | 100 |
| 'Icon' EC | 5.0 | 100 | 100 | 100 | 100 |
| bendiocarb WP | 100.0 | 100 | 67 | 93 | 98 |
| propoxur WP | 440.0 | 17 | 0 | 0 | 0 |
| cyfluthrin EC | 5.0 | 100 | 100 | 70 | 99 |
| cyfluthrin EC | 10.0 | 100 | 100 | 100 | 100 |
| cypermethrin EC | 20.0 | 100 | 100 | 100 | 100 |
| deltamethrin EC | 2.5 | 100 | 100 | 83 | 98 |
| deltamethrin EC | 5.0 | 100 | 100 | 100 | 73 |

* 24 hour kill (percent), exposed for one hour.

**Unglazed porous tiles (UK)**

100% kill was maintained for 16 weeks after treatment (Fig. 3).

**Various substrates – Microcapsules**

'Icon' microcapsules were still 100% active after 8 weeks on mud, mud brick and whitewash and after 11 weeks on cement blocks. All these surfaces rapidly break down most residual insecticide formulations.

**Residual activity of 'Icon' microcapsules on various substrates (Tanzania)***

| Substrate | 1 WAT | 4 WAT | 6 WAT | 8 WAT | 11 WAT |
|---|---|---|---|---|---|
| Mud | 97 | 100 | 100 | 100 | – |
| Whitewash | 100 | 100 | 100 | 100 | – |
| Mudbrick | 75 | 60 | 100 | 100 | – |
| Cement block | 100 | – | 89 | – | 100 |
| Thatch | 100 | 100 | 100 | – | – |
| Wood | 100 | 100 | 100 | – | – |

* Kill% of *Anopheles gambiae* exposed for one hour, 24 hours after exposure. Application rate 30mg ai/m². WAT = Weeks after treatment.

**Impregnated fabrics**

Pyrethroid treatment of fabrics used for bednets and curtains, for protection against mosquitoes is now well established and used as an adjunct to other methods of personal protection against mosquitoes (WHO,1989). This technique could also have an impact on controlling the vectors of arboviruses and lymphatic filariasis.

'Icon' has been found to be very effective for this purpose. Tests on its effectiveness on several fabrics have been carried out at a number of centres, for example, at the London School of Hygiene and Tropical Medicine, UK.

The studies reported here were initiated to investigate fully the different pyrethroid /fabric combinations and to determine the optimum combination for field use (Fig. 4). (Miller, 1990).

On treated nylon netting, 'Icon' is six times more effective than deltamethrin and more than 200 times as effective as permethrin at the $LC_{50}$ level. Comparing cotton, nylon and polyester (ICI 'Terylene'), bioassays showed that the insecticides exhibited the greatest activity when applied to nylon, except in the case of permethrin which was more active on 'Terylene'. The combination with the highest insecticidal activity was nylon treated with 'Icon'.

For field purposes, the differences between nylon and cotton are not so great that it would be worth switching from locally produced cotton nets, if they are already in widespread use, to nylon ones. If a control programme is introducing nets impregnated with 'Icon' for the first time, then the fibre of choice would be nylon.

#### 4.1.3. LARVICIDAL ACTIVITY

Two Collaborating Centres for the World Health Organisation (WHO) have reported on the activity of 'Icon' as a mosquito larvicide:

**(1)** Orstom – Laboratoire d'entomologie medicale, Bondy, France
As part of the WHOPES programme this centre determined the $LD_{50}$ and $LD_{90}$ of two mosquito species, using 4th instar larvae with 24 hour exposure. (Coz *et al.*, 1984).

**Mosquito larvicide trials – $LD_{50}$ and $LD_{90}$ mg/l (France)**

| *Aedes aegypti* | | *Anopheles stephensi* | |
|---|---|---|---|
| $LD_{50}$ | $LD_{90}$ | $LD_{50}$ | $LD_{90}$ |
| 0.00042 | 0.00118 | 0.0014 | 0.0144 |

**(2)** University of California, Riverside, USA
'Icon' was tested with serial dilutions against the larvae of two mosquito vector species, (*Culex faciatus* and *Anopheles albimanus*). Regression analysis of the dose response gave $LC_{50}$ and $LC_{95}$ values as in the table below (Univ. of California, Riverside, 1985).

**Susceptibility of larvae tested with lambda-cyhalothrin (USA)**

| | $LD_{50}$ ppm | $LD_{95}$ ppm |
|---|---|---|
| *C. fasciatus*: susceptible | 0.00045 | 0.00074 |
| *An. albimanus*: susceptible | 0.012 | 0.053 |
| *An. albimanus*: OP/carbamate resistant | 0.017 | 0.11 |

Results: The data show 'Icon' to be a potent larvicide without cross-resistance to other classes of secticide.

In addition, Sulaiman *et al.* (1991) evaluated the pyrethroids lambda-cyhalothrin, deltamethrin and permethrin in the laboratory against *Aedes albopictus* using 4th instar larvae, 24 hour exposure. Lambda-cyhalothrin was more effective than deltamethrin or permethrin. The $LC_{99}$ values were as follows:

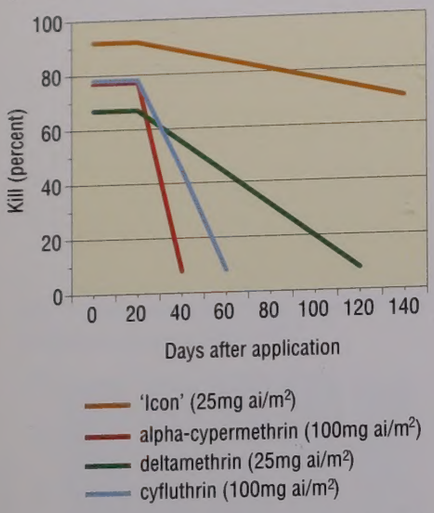
| | $LC_{99}$ values |
|---|---|
| 'Icon' (lambda-cyhalothrin) | $1.53 \times 10^{-7}$ % ai |
| deltamethrin | $6.46 \times 10^{-1}$ % ai |
| permethrin | $5.25 \times 10^{-4}$ % ai |

### 4.2 Field evaluation

#### 4.2.1. RESIDUAL CONTROL OF *ANOPHELINE* MOSQUITOES

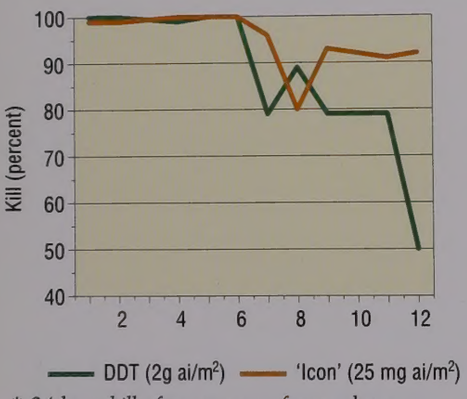
Low rates of 'Icon' 10WP, applied as a residual spray to houses in tropical countries, have given prolonged control of mosquito vectors of malaria. A sachet containing 62.5g of 10%

**Fig. 5. Residual effects of pyrethroid WP products on *Anopheles aconitus* (Indonesia)***



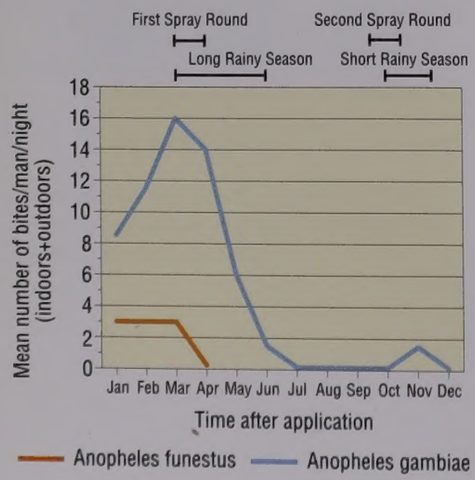

** kill% of Anopheles aconitus exposed for 30 minutes to pyrethoid WP.*

**Fig. 6. Kill of *Anopheles darlingi* exposed to walls sprayed with 'Icon' 10WP or DDT WP (Brazil)***




** 24 hour kill after exposure for one hour.*

**Fig. 7. Reduction in biting rate (Tanzania)***
** reduction in man biting rate (indoors and outdoors) after residual spraying with **'Icon'** 10WP (30mg ai/m²).*




wettable powder 'Icon' formulation is suitable for charging a compression sprayer of 8 or 10 litres capacity for application rates of 25-30 mg ai/m².

**(1) Indonesia**

Field trials in Indonesia, as part of the WHO evaluation scheme, have compared several pyrethroids for residual effectiveness, when applied as WP formulations (Fig. 5). Treated houses were bio-assayed with *Anopheles aconitus* (Barodji *et al.*,1989).

'Icon' at one quarter the rate of cyfluthrin and alpha-cypermethrin provided markedly better control. When used at the same rate as deltamethrin, 'Icon' provided much greater residual control.

**(2) Brazil**

In Brazil, 'Icon' WP at 25mg ai/m² was compared with 2g ai/m² of DDT WP for the control of the vector *Anopheles darlingi.* Persistence was monitored by bio-assays with the vector in sprayed houses (SUCAM,1988) (Fig. 6). 'Icon' was very favourably received by the householders due to the lack of visible deposits and excellent control of other domestic insects.

The 'Icon' treated walls remained active against the vectors for 12 months after treatment, whereas mortality in the area with DDT treated walls started to drop after 7 months.

### 4.2.2 EFFECT ON MALARIA TRANSMISSION

**WALL SPRAYS**

**(1) Tanzania**

In the coastal belt of Tanzania, malaria is transmitted by the highly efficient vectors *Anopheles funestus* and *Anopheles gambiae.* Malaria is hyperendemic or holoendemic in the trial area and this site was the main Phase 3 epidemiological trial for 'Icon' under the WHOPES scheme. These vectors were controlled by residual house-spraying with 'Icon' at an application rate of 30mg ai/m² twice per year during 1988-1990. Rates of coverage were 97-99% without refusals, showing the popularity of 'Icon' with householders (Tanzania National Institute for Medical Research,1988).

After the first spray round in 1988, *Anopheles funestus* disappeared from the sprayed villages and *An. gambiae* no longer occurred indoors (Fig. 7). During subsequent rainy seasons, densities of both vectors rose slightly but their vectoral capacity remained low (as judged from parous rates below 50%).

Malaria transmission rates were suppressed for 4-6 months after each spray round leading, after a few months, to a progressive decline in the prevalence of malaria in the human population. In particular, the risk of newly born children being infected with malaria was more than four times lower in the 'Icon' sprayed areas compared with the unsprayed areas.

In view of the successful impact of 'Icon' on malaria transmission rates in this most malarious part of Africa, WHO concluded that 'Icon' should be added to the list of insecticides suitable for use in malaria control operations.

**(2) Nepal**

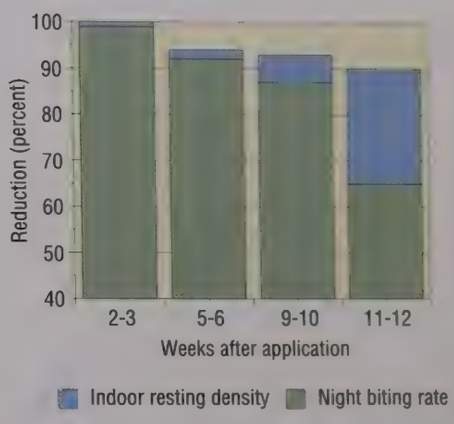
Village scale field trials of antimalaria house spraying were conducted in the Terai area of Nepal, to evaluate 'Icon' against *Anopheles annularis, An. culicifacies, An. fluviatilis, An. maculatus* and other potential malaria vectors. *Anopheles annularis* is the main vector and shows DDT resistance. 'Icon' was sprayed onto the interior walls and ceilings and around the eaves of the houses, at a rate of 25mg ai/m² (Shrestha *et al.*,1989) (Fig. 8).

Bioassay mortality of 97-100% for at least 19 weeks on treated wood and thatch

surfaces and 80-100% for 12 weeks on the brick and mud surfaces were obtained. Substantial reductions of anopheline densities and parity rates were found among specimens collected indoors – either resting or biting cattle or people.

With two spray rounds, malaria vector control was achieved throughout the transmission season. This lead to a reduction of malaria prevalence from an Annual Parasite Incidence (API) of 13.4 in 1987 after spraying DDT and bendiocarb, to an API of 5 in 1988 after spraying with 'Icon'.

**Fig. 8. Mosquito reduction (%) in houses treated with 'Icon' WP (Nepal)**




**BEDNETS**

**The Gambia: Medical Research Council Laboratories**

Field trials and additional laboratory studies in The Gambia have confirmed that 'Icon' is particularly active against *Anopheles* species on treated bednets, (Miller *et al.*, 1991).

In one trial, bednets were impregnated with emulsions of cypermethrin, deltamethrin, lambda-cyhalothrin ('Icon'), permethrin and pirimiphos-methyl. Gas liquid chromatography showed that the dosages applied were 37, 10, 3, 670 and 4017 mg/m$^2$, respectively. There were significant losses of cypermethrin, permethrin and pirimiphos-methyl after 12 weeks but not of deltamethrin or 'Icon'. After nets were hand-washed 3 times, dosages of all actives were reduced by at least 85%.

A field trial lasting six weeks was carried out to test washed and unwashed nets with each of these insecticides in experimental huts (verandah-trap) against the mosquitoes : *Anopheles gambiae s.l.* and *Mansonia* spps.

The permethrin EC formulation (either the active ingredient or the adjuvants composing the formulation) strongly deterred mosquitoes from entering the huts. This would benefit the individual net user but the mosquitoes might be diverted to other unprotected members of the community. Deterrence did not occur with any other of the net treatments.

Killing mosquitoes would benefit the whole community. This occurred with all net treatments but was much reduced after washing. The lowest percentage of *Anopheles gambiae* killed on the treated nets came from those treated with permethrin. The highest rates of mosquito mortality were caused by nets treated with 'Icon' and pirimiphos-methyl.

**4.2.3 SPACE TREATMENTS**

Applied as a thermal fog or cold aerosol (ULV), 1-2g ai/ha of 'Icon' gives excellent control of flying mosquitoes.

**THERMAL FOG**

In trials in Malaysia, *Aedes aegypti* were held in cages at various distances from application of a thermal fog of 'Icon' diluted in diesel and applied at a volume of 2 litres per hectare.

**'Icon' Fog – Knockdown and kill – *Aedes aegypti* (Malaysia)***

| Rate (g ai/ha) | Distance from source | | | |
|---|---|---|---|---|
| | 10 metres | | 50 metres | |
| | KD | | Kill | |
| 0.25 | 37 | 95 | 18 | 68 |
| 0.5 | 63 | 96 | 64 | 79 |
| 1.0 | 83 | 100 | 33 | 79 |
| 2.0 | 96 | 100 | 62 | 96 |

* knockdown (% at 15 minutes) and kill (% at 24 hours).

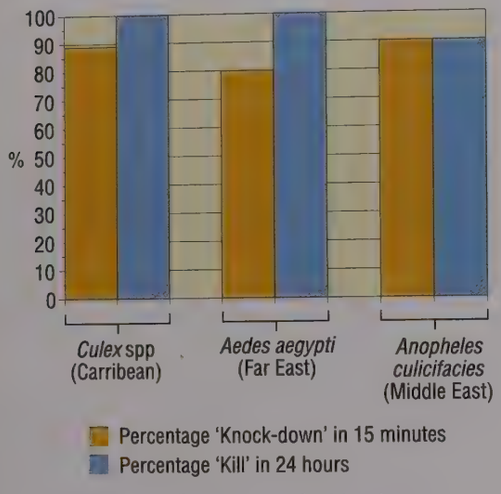
A comparable experiment demonstrated the increased speed of knockdown that can be obtained by the addition of synergised pyrethroid knockdown agents.

**'Icon' Fog mixture – Knockdown and kill – *Aedes aegypti* (Malaysia)***

| Rate (g ai/ha) | Distance from source | | | |
|---|---|---|---|---|
| | 10 metres | | 50 metres | |
| 1.0 | 100 | 100 | 71 | 99 |
| 2.0 | 100 | 100 | 94 | 100 |
| 4.0 | 100 | 100 | 91 | 100 |

* 15 minute knockdown (KD) and 24 hour kill (percent) from 'Icon' as a fog in mixture with a synergised knockdown agent.

**Fig. 9. 'Icon' applied as a cold aerosol ULV against mosquito targets***




** Applied at 1g ai/ha, measured 100m from sprayer.*

**COLD AEROSOL (ULV)**

'Icon' is also highly effective when applied as a cold aerosol (ULV) space spray (Fig. 9). This figure shows the excellent results achieved when 'Icon' is diluted with diesel oil and applied against *Culex, Aedes* and *Anopheles* mosquitoes. Extended drift of the aerosol cloud, by using diesel, coupled with the high activity of 'Icon' means that it is frequently possible to control mosquitoes over 100 metres from the aerosol generator.

# House Flies

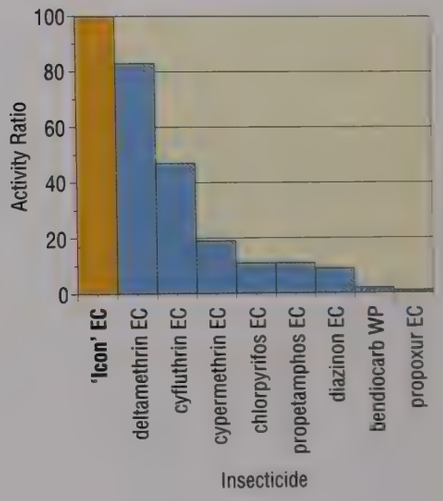
## 5.1 Laboratory studies

### 5.1.1 INTRINSIC ACTIVITY

'Icon' is more active than deltamethrin and more than five times as active as cypermethrin when applied as a direct spray to the WHO susceptible strain of house flies, *Musca domestica* (Fig. 10).

In a similar trial, 'Icon' showed increased activity against a Middle East field strain of flies when compared to a range of carbamate and organophosphorus insecticides.

**Fig. 10. Effect of direct spray on adult *Musca domestica* (UK)**




**Ratio of activity of insecticides from topical application to a Middle East strain of *Musca domestica* (UK)**

| Insecticide | 50% control | 90% control |
|---|---|---|
| [illegible] | [illegible] | [illegible] |
| propoxur EC | 5 | >5 |
| diazinon EC | 3 | 3 |
| dichlorvos EC | 2 | 2 |
| chlorpyrifos EC | 2 | 1 |
| bendiocarb EC | >1 | >5 |
| fenitrothion EC | 1 | 1 |

'Icon' was 250 times more active than either chlorpyrifos or fenitrothion and 50 times more active than bendiocarb.

When applied to filter papers, 'Icon' was more than six times more active than cypermethrin against WHO susceptible flies.

**Lethal concentration (mg ai/m²) of 'Icon' to WHO susceptible *Musca domestica* (Malaysia)***

| Insecticide | $LC_{50}$ | $LC_{90}$ |
|---|---|---|
| [illegible] | [illegible] | [illegible] |
| cypermethrin EC | 193 | 324 |
| pirimiphos methyl WP | 279 | 437 |

* on filter paper

Against the blowfly *Chrysomyia megacephala* in a filter paper test 'Icon' was nearly eight times more active than cypermethrin.

**Lethal concentration (mg ai/m²) of 'Icon' to *Chrysomyia megacephala* (Malaysia)***

| Insecticide | $LC_{50}$ |
|---|---|
| [illegible] | [illegible] |
| cypermethrin EC | 124 |

* on filter paper

### 5.1.2 SPACE TREATMENT

**'Icon' sprayed in a wind tunnel against *Musca domestica* (UK)**

| Insecticide | Concentration (% ai) | Kill % (24 hours after treatment) |
|---|---|---|
| [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] |
| permethrin EC | 0.15 | 93 |
| permethrin EC | 0.25 | 100 |

'Icon' shows about twenty times the activity of permethrin when sprayed in a wind-tunnel containing a field strain of organophosphorus-resistant flies.

### 5.1.3 RESIDUAL ACTIVITY

'Icon' is exceptionally persistent on inert surfaces; low rates of application control adult house flies for many weeks.

Experiments in the laboratory in which the WHO susceptible strain of flies was exposed for one hour to plywood sprayed with various insecticides, demonstrated that 'Icon' is one of the most active and persistent insecticides available.

**Comparison of effect on *Musca domestica* of various insecticides after exposure on treated plywood (UK)***

| Insecticide | Rate (mg ai/m²) | Weeks after application | | | |
|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 10 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| deltamethrin EC | 10 | 93 | 50 | 33 | – |
| cyfluthrin EC | 10 | 87 | 40 | – | – |
| cypermethrin EC | 40 | 63 | 53 | 13 | – |
| bendiocarb WP | 100 | 93 | 93 | 23 | – |
| propetamphos EC | 200 | 100 | 87 | 53 | – |
| propoxur EC | 440 | 23 | 37 | – | – |

* 48 hour kill (percent) after exposure for one hour.

'Icon' showed greater persistence than any of the other standard insecticides tested. When used at a higher rate in another test, 'Icon' gave complete control for 12 weeks.

**Comparison of effect on *Musca domestica* of various insecticides after exposure on treated plywood (UK)***

| Insecticide | Rate (mg ai/m²) | Weeks after application | | | |
|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 12 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| cypermethrin EC | 50.0 | 97 | 100 | 97 | 97 |
| fenitrothion EC | 500.0 | 85 | 67 | 47 | 0 |

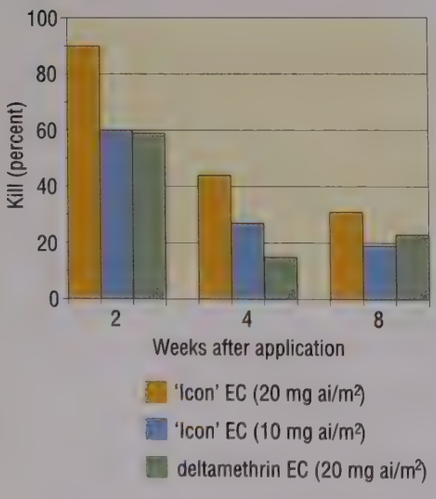
* 48 hour kill (percent) after exposure for one hour.

Under Malaysian conditions, 'Icon' was again more active than deltamethrin when applied to plywood (Fig. 11).

The CS formulation performs well (> 80% control) against *Musca* spp over 3 months on cement, with a significant improvement over 'Icon' 10WP.

As stated before, 'Icon' is very persistent on glass. Even at the very low rate of 3mg/m², 'Icon' gave 100% control for over eight weeks. 'Icon' was at least eight times more effective than permethrin and twenty times more effective than bendiocarb.

**Fig. 11. Comparison of 'Icon' and other pyrethroids on *Musca domestica* after exposure on treated plywood (Malaysia)***




** 24 hour kill (percent) after exposure for one hour.*

## 5.2 Field evaluation

### 5.2.1 SPACE TREATMENT

#### Fogs

Fog or ULV space treatments with 'Icon' used alone give excellent control of house flies. The speed of knockdown can be increased by the addition of specific knockdown agents.

In experiments in Oman using 'Icon' alone, diluted product was applied as a thermal fogs in a volume of 2 litres per hectare. *Musca domestica* were held in cages at various distances from the line of application.

**'Icon' applied as a thermal fog: *Musca domestica* (Oman)***

| Rate (g ai/ha) | Distance from source | | | |
|---|---|---|---|---|
| | 10 metres | | 50 metres | |
| | KD | Kill | KD | Kill |
| 2.5 | 93 | 100 | 80 | 100 |

* 15 minute knockdown and 24 hour kill (percent).

'Icon' gives very effective kill and knockdown when used alone.

When it is necessary to increase the 'knockdown' effect of 'Icon', one of a range of specialist formulations, which contain synergized pyrethroid knockdown agents can be used (Fig. 12).

The synergist both increases the speed of paralysis of the insects and prolongs the useful life of the killing agent. When applied at the recommended rate, at a distance of 25 metres, 50% of the flies are knocked down within 3.5 minutes of application and 90% within 15 minutes.

#### Cold aerosol ULV

Formulations of 'Icon' with synergised knockdown agents also give rapid knockdown and almost complete control of flies when applied ULV using 0.5 litres per hectare. However, when spraying outdoors, there is an inevitable and rapid reduction in droplet size due to evaporation if the diluent/carrier is water, particularly at distances exceeding 25 metres. The bio-efficacy of these shrunken droplets against larger insect target pests is poor when compared with that from non-evaporating oil based droplets. The much more efficient control of house flies by 'Icon' diluted with commercial diesel oil, compared with the water-miscible formulation 'Aqua Reslin' at distances in excess of 25 metres, is illustrated in Fig. 13.

'Icon' is intrinsically more active and combined with the more efficient oil based droplets gives 90% control even at 100 metres from the ULV generator compared to 30% control with 'Aqua Reslin'.

### 5.2.2 RESIDUAL CONTROL

With high intrinsic activity and long persistence on inert surfaces, residual applications of 'Icon' give many weeks control of adult house flies. In southern Africa 'Icon' WP was applied at 10 mg ai/m² to the walls and roof of horse stables where flies were breeding in uncleared manure (Fig. 14).

Indices of the fly population showed almost complete control throughout the 10 week assessment period.

**Fig. 12. 'Icon' applied as a thermal fog: *Musca domestica* (wild caught) (UAE/Middle East)**

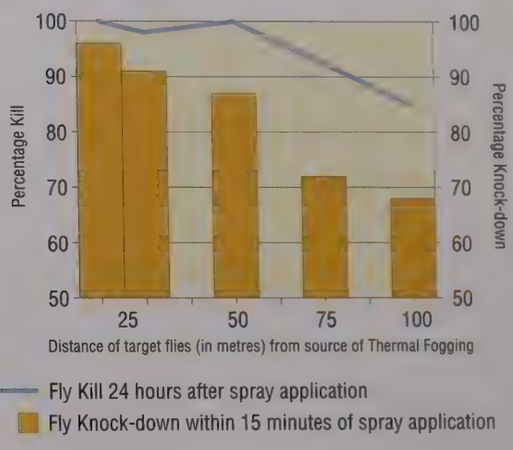



**Fig. 13. Comparison of 'Icon' (oil) and 'Aqua Reslin' (water) against *Musca domestica* (wild caught) (UAE/Middle East)**

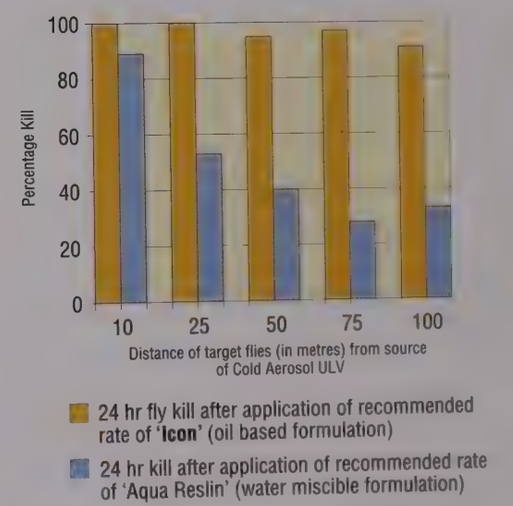
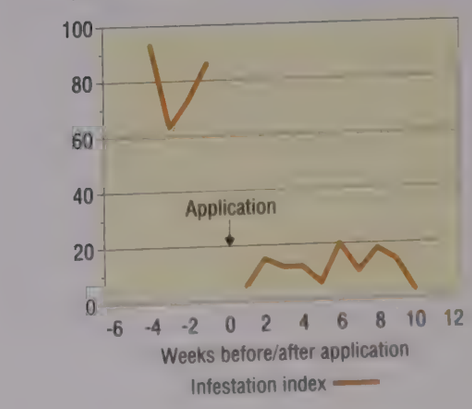
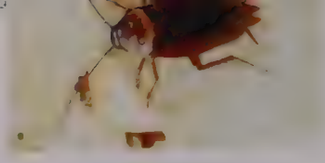



**Fig. 14. Index of the adult fly population before and after a residual spray of 'Icon' WP (Zimbabwe)**





# 6 Cockroaches

## 6.1 Laboratory studies

### 6.1.1 INTRINSIC ACTIVITY

Topical applications of a variety of insecticides have demonstrated the activity of 'Icon' against the German cockroach *(Blattella germanica)* and the American cockroach *(Periplaneta americana)*. In this experiment mortality was assessed two days after treatment (Fig. 15a & b).

'Icon' has twice the activity of cyfluthrin. Compared with bendiocarb, 'Icon' is 11 times more active against *Blattella germanica,* but 25 times more active against *Periplaneta americana.*

A WHO collaborating laboratory in the USA, Virginia Polytechnic Institute and State University, calculated the lethal concentration of 'Icon' to 50% of *Blatella germanica* ($LC_{50}$) to be 24 µg ai/cm² from a two hour exposure to technical lambda-cyhalothrin and 13 nl/cm² for 25 minutes exposure to a 5% EC formulation (Cochran, 1986).

The intrinsic activity of 'Icon' EC and cypermethrin EC against *Blatta orientalis* has been determined using a direct spray.

**Lethal concentration (ppm ai) of 'Icon' EC or cypermethrin EC against *Blatta orientalis* as direct sprays (UK)**

| Insecticide | $LC_{50}$ | $LC_{90}$ |
|---|---|---|
| [illegible] | [illegible] | [illegible] |
| cypermethrin EC | 94 | 156 |

The results indicate that 'Icon' is approximately 3.5 times more active than cypermethrin against this species.

### 6.1.2 FLUSHING EFFECT

Though 'Icon' has excellent flushing activity, its fumigant effect is limited as would be expected from its low vapour pressure. This suggests that flushing activity is a sub-lethal response to minute airborne droplets which penetrate the harbourages. The insects then pick up a lethal dose when they escape into the open.

In a laboratory test, insecticides diluted in kerosene were sprayed into a standard Peet-Grady Chamber at 1 mg ai/m³.

**Effect on *Blatella germanica* of various pyrethroids as space sprays in kerosene (USA)***

| Insecticide | Flush-out % | | Kill % |
|---|---|---|---|
| | 5 minutes | 30 minutes | 24 hours |
| [illegible] | [illegible] | [illegible] | [illegible] |
| cypermethrin | 21 | 70 | 99 |
| permethrin | 2 | 22 | 1 |
| synergised pyrethrins | 5 | 17 | 4 |

* Flush-out and 24 hour kill (percent). Applied at 1 mg ai/m³.

**Fig. 15a. Ratio of activity for kill of *Blattella germanica* from a direct spray (UK)**

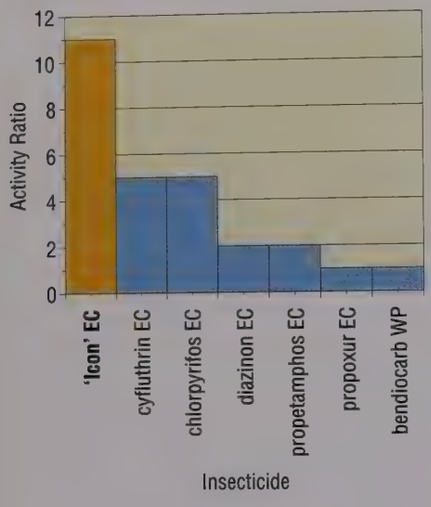
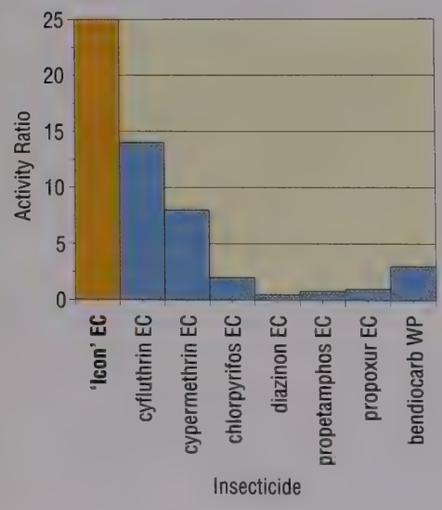



**Fig. 15b. Ratio of activity for kill of *Periplaneta americana* from a direct spray (UK)**



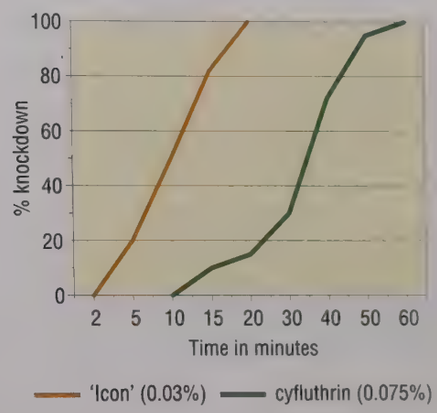
'Icon' caused almost all *Blattella germanica* to leave their harbourage within thirty minutes, resulting in their death within 24 hours.

### 6.1.3 KNOCKDOWN

'Icon' shows particularly fast action as the data in Fig. 16 reveals (ICI Americas, 1989).

Using 'Icon' 10WP, 100% knockdown of *Blattella germanica* was found after only 20 minutes continual exposure. This was 3 times faster than knockdown with cyfluthrin at twice the rate of active ingredient.

**Fig. 16. Knockdown (mean %) of German cockroach adults: 'Icon' vs. cyfluthrin (USA)**




### 6.1.4 RESIDUAL ACTIVITY ON VARIOUS SUBSTRATES

'Icon' applied to a great variety of surfaces, including plywood, painted wood, greasy metal, ceramic and concrete, will control *Blattella germanica* for many weeks. The following results from the USA are typical.

**Kill (percent) of *Blattella germanica* after exposure to substrates sprayed with insecticides (USA)***

| Insecticide | Rate (mg ai/m²) | Weeks after application | | | |
|---|---|---|---|---|---|
| | | 0 | 4 | 8 | 14 |
| **Plywood** | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| chlorpyrifos EC | 135 | 0 | 50 | 0 | – |
| diazinon CS | 540 | 10 | 0 | 0 | 0 |
| propetamphos EC | 540 | 0 | 0 | 0 | 0 |
| **Painted wood** | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| propoxur WP | 594 | 90 | 30 | 0 | 0 |
| **Greasy metal** | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| chlorpyrifos EC | 135 | 50 | 0 | 0 | 0 |

* one hour after exposure.

On plywood, total kill is given up to 14 weeks after application at 54mg ai/m². Similar performance was found on a greasy metal surface up to 8 weeks, while up to 4 weeks was given on painted wood.

**Substrate: Plywood**

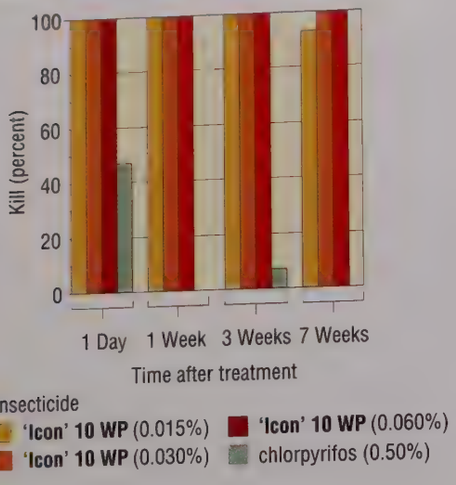
A broader range of commercial standards were tested in comparison with 'Icon' on plywood in the UK using *Blattella germanica*.

**Effect on *Blattella germanica* after exposure to plywood sprayed with various insecticides (UK)***

| Insecticide | Rate (mg ai/m²) | Weeks after application | | |
|---|---|---|---|---|
| | | 4 | 8 | 12 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| deltamethrin EC | 6 | 100 | 93 | 67 |
| cypermethrin EC | 25 | 80 | 73 | 62 |
| permethrin EC | 50 | 60 | 7 | 0 |
| diazinon EC | 2000 | 33 | 0 | – |
| chlorpyrifos EC | 1500 | 100 | 80 | 7 |
| fenitrothion EC | 2000 | 100 | 60 | 7 |
| bendiocarb WP | 300 | 93 | 8 | 0 |
| propoxur WP | 1000 | 100 | 75 | 0 |

* 48 hour kill (percent) after exposure for one hour.

**Fig. 17 Efficacy of 'Icon' 10WP vs. chlorpyrifos against American Cockroaches adults on unpainted plywood (USA)**




'Icon' shows greater activity than deltamethrin and well in excess of four and eight times the activity of cypermethrin and permethrin respectively.

The prolonged control of both *P. americana* and *B. germanica* by 'Icon' 10WP is demonstrated by laboratory bioassays.

**'Icon' 10WP single application: laboratory bioassays on cockroaches (UK)**

| Target species | Rate (mg ai/m²) | Weeks after application | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 12 | 16 | 24 |
| *Blattella germanica* | 10 | 100 | 100 | 100 | 100 | 100 | 100 |
| *Periplaneta americana* | 10 | 100 | 100 | 100 | 100 | 100 | 100 |

Excellent control over 24 weeks was achieved after a single application of 'Icon' 10WP.

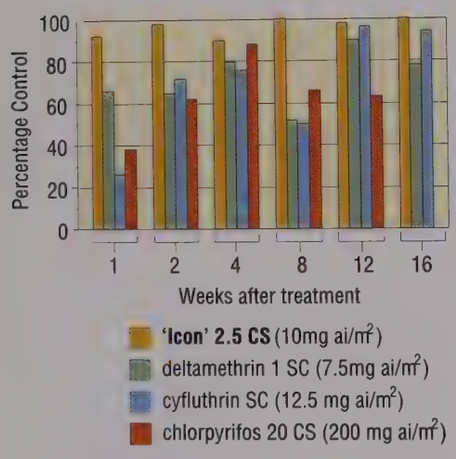
The efficacy of 'Icon' 10 WP against the American Cockroach adults on unpainted plywood in comparison with chlorpyrifos is given in Fig. 17. Excellent kill was achieved at all rates. 'Icon' was significantly superior to chlorpyrifos. (ICI Americas, 1988).

Using 'Icon' 2.5CS, 16 weeks control (100% mortality) was achieved on a 'semi-porous' surface (unpainted plywood) at a maintenance rate of 10 mg ai/m². This was superior to the performance of all other pyrethroids tested. (Fig.18).

**Substrate: Glass**

On glass, 'Icon' showed exceptional persistence compared with other products.

**Fig. 18 Efficacy of 'Icon' 2.5CS against *Blatella germanica* (susceptible) on unpainted plywood* (UK)***




** 30 second exposure; 30 minute KD, 48 hour mortality*

**Effect on *Blattella germanica* after exposure to glass sprayed with various insecticides (UK)***

| Insecticide | Rate (mg ai/m²) | Weeks after application | | |
|---|---|---|---|---|
| | | 4 | 8 | 12 |
| deltamethrin EC | 6 | 100 | 93 | 67 |
| diazinon EC | 1000 | 0 | 0 | 0 |
| chlorpyrifos EC | 1500 | 100 | 11 | 0 |
| fenitrothion EC | 1000 | 100 | 7 | 0 |
| bendiocarb WP | 300 | 100 | 93 | 0 |
| propoxur WP | 500 | 100 | 0 | 0 |

* 48 hour kill (percent) after exposure for one hour.

'Icon' gave 100% control for 12 weeks at an application rate of only 3mg ai/m². None of the standard insecticides tested persisted at this level beyond 4 weeks except bendiocarb, which performed well up to 8 weeks, but at 100 times the concentration at which 'Icon' was used.

**Effect of various insecticides sprayed on glass on male *Periplaneta americana* (UK)***

| Insecticide | Rates (mg ai/m²) | Weeks after treatment | | | |
|---|---|---|---|---|---|
| | | 2 | 6 | 10 | 24 |
| bendiocarb | 500 | 88 | 100 | 100 | 100 |
| propoxur | 500 | 100 | 100 | 22 | – |
| fenitrothion | 500 | 100 | 78 | 0 | – |
| chlorpyrifos | 500 | 100 | 67 | – | – |

* 24 hour kill (percent) after one hour exposure.

25mg ai/m² of 'Icon' gave complete control of *Periplaneta americana* throughout a 6 month period. Of the other compounds applied at twenty times the rate, only bendiocarb gave similar control .

**Substrate: Unglazed tiles**

To show the persistence of 'Icon' on a very challenging porous substrate, it was sprayed on unglazed tiles and bio-assayed at intervals with *Blattella germanica* (Fig. 19).

'Icon' at 20 mg ai/m² gave complete control for more than 23 weeks, whereas propoxur at 88 times this rate only gave 50% control at this time.

## 6.2 Field evaluation

In the Caribbean, 'Icon' and propoxur were sprayed in residential premises infested with cockroaches, mainly *Blattella germanica* (Fig. 20).

After 12 weeks, there was an average 89% reduction in infestation in premises sprayed with 'Icon' at 0.02% ai.

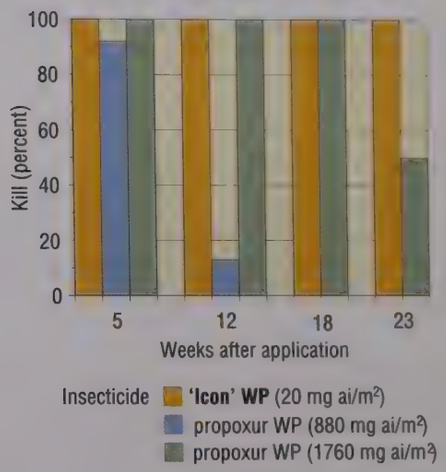
A further example of the efficiency of 'Icon' in clearing out German cockroaches from urban housing is given in data from Florida (Fig. 21).

Excellent control was obtained under adverse conditions. Superior activity compared with chlorpyrifos was demonstrated (University of Florida, 1988).

In USA, 'Icon' 10CS (microcapsules) were tested in apartment kitchens in Texas, heavily infested with German cockroaches. The products were applied by compressed air sprayers fitted with both coarse fan spray and crack and crevice nozzles.

Both products, applied at 0.015% concentration, reduced the cockroach population by over 70% during the first 21 days. At 60 days after treatment, both products had reduced the population by 93%.

**Fig. 19. Effect on *Blattella germanica* after exposure to unglazed tiles sprayed with 'Icon' WP or propoxur WP (UK) ***




** 48 hour kill (percent) after exposure for one hour.*

**Fig. 20. Reduction in infestation of cockroaches in premises sprayed with insecticides (Caribbean)**

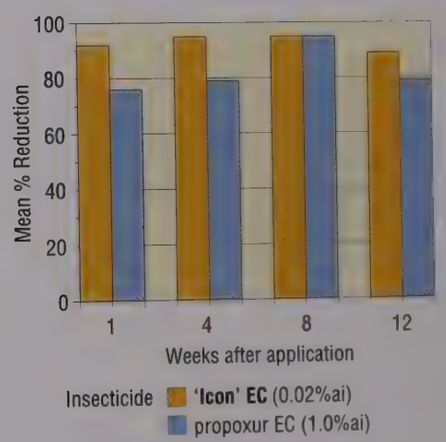
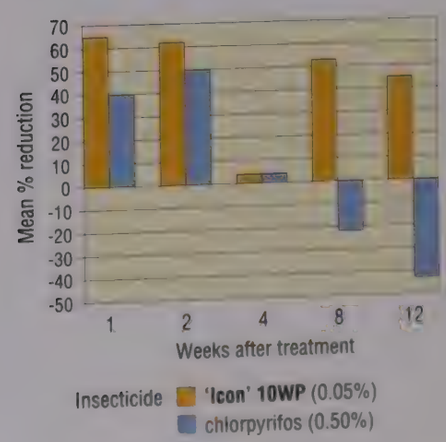


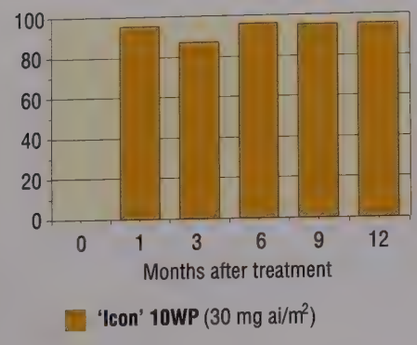

**Fig. 21. Reduction in infestation of cockroaches: 'Icon' 10WP vs. chlorpyrifos, Gainesville Housing Authority (USA)**



# Reduviid Bugs

Laboratory and field studies have shown that 'Icon' will give prolonged control of Reduviid bugs, which vector Chagas' disease in Latin America.

**Fig. 22. Control (%) of Reduviid bugs (*Triatoma sordida*) after treatment with 'Icon' 10WP (Brazil).**




## 7.1 Laboratory studies

The Federal University of Rio de Janeiro, as the WHO Collaborating Laboratory for Chagas' disease control, showed that 'Icon' is highly effective against triatomine bugs (Oliveira Filho,1991).

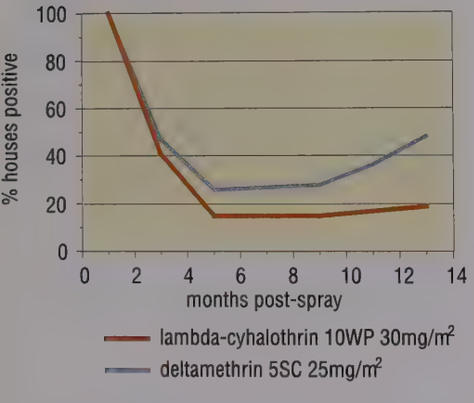
| Insect species | Dose | $LD_{50}$ | $LD_{90}$ |
|---|---|---|---|
| *Triatoma infestants* | µg ai/nymph | 0.032 | 0.065 |
| *Triatoma sordida* | µg ai/nymph | 0.18 | 1.00 |
| *Triatoma brasiliensis* | µg ai/nymph | 0.0272 | 0.0848 |
| *Panstrongylus megistus* | µg ai/nymph | 0.10 | 0.30 |
| *Rhodnius prolixus* | µg ai/nymph | 0.0298 | 0.1317 |

## 7.2 Field evaluation

Field trials in Brazil (District of Formosa) clearly demonstrate the efficacy of 'Icon' 10WP applied to the walls of houses for the control of Reduviid bugs (Fig. 22).12 months after application, a high level of control was still being achieved (Dept. of Eradication and Disease Control, Chagas Division, Brazil, 1988).

In further Brazilian field trials, the benefits of 'Icon' (lambda-cyhalothrin) over deltamethrin over a 12 month period are clearly shown. (Fig.23).

**Fig. 23. Control (%) of Reduviid bugs (*Triatoma infestans*) after treatment with 'Icon' 10WP (Brazil).**




*Mean results obtained in 3 trials: Arraias 1987, Posse 1988, Uberaba 1988.*

# 8 Tsetse Flies

## 8.1 Laboratory studies

The intrinsic activity of 'Icon' has been determined against the tsetse flies *Glossina austeni* and *G. morsitans* when applied to the thorax (ODNRI,1986).

**Lethal dose (ng ai/insect) of 'Icon' to 50% of tsetse flies (UK)**

| Insecticide | *Glossina austeni* | *Glossina morsitans* |
|---|---|---|
| [illegible] | [illegible] | [illegible] |

When individual *G. morsitans* were exposed for one minute to plywood panels treated with 25mg ai/m² of 'Icon', complete control was obtained throughout the 12 week evaluation period.

Previous residual tests against tsetse on plywood had been made with *G. austeni* at the higher dose of 50mg ai/m², so that direct comparison is not possible. However species susceptibility tests by topical application with permethrin and deltamethrin on teneral tsetse flies suggest that *G. morsitans* is only marginally more susceptible than *G. austeni.*

**Effect of insecticides on tsetse flies on treated plywood (UK)***

| Insecticide | Rate (mg ai/m²) | Weeks after application | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 2 | 4 | 8 | 12 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| permethrin WP | 50 | 71 | 79 | 75 | – | – |
| endosulfan WP | 50 | 77 | 0 | – | – | – |
| dieldrin WP | 50 | 8 | 0 | – | – | – |

* kill % at 48 hours after exposure on treated panels.

'Icon' 10WP still gave 100% control after 12 weeks exposure.

## 8.2 Field evaluation

'Icon' has been tested in the field in Zimbabwe for treating netting targets. A weather resistant oil-based formulation of 'Icon' was compared with 'Icon' 10WP. Both were used at a rate of 50mg/m². Mortality assessments before and after treatment showed that the oil-based formulation maintained 100% control of *Glossina* spp. landing on the targets for 6 months. At 10 months it was still giving 50% control. In contrast, control with 'Icon' 10WP started to decline at 2 months and by 4 months was almost nil (Fig. 24) (Langley,1991).

In Uganda, 'Icon' was tested in field trials against *Glossina f. fuscipes* and the effect on sleeping sickness transmission in a sub-county of Tororo District (Okoth *et al.*, 1990). The insecticide was applied by selective bush spraying, using 'Icon' 10WP in one area with a single application rate of 11.6g ai/ha over an area of 28km². In another area of 30km², an oil based formulation of 'Icon' was used, giving 2 applications of 0.9g ai/ha in November 1988 and April 1989. The comparison area, covering 10km², was left untreated until April 1989 when it too was sprayed with 'Icon', leaving only a small uninhabited area for monitoring purposes.

Monitoring of the tsetse population was based on regular sampling with untreated biconical traps. The greatest impact was obtained with 'Icon' 10WP, which eliminated tsetse within 1-2 months (Fig. 25).

The numbers of human sleeping sickness cases fell to no more than 1 per month, compared to a previous rate of 4-12 cases per month (Fig. 26).

**Fig. 24. Mortality of *Glossina* spp. in relation to age of treated netting exposed under natural conditions (Zimbabwe)**

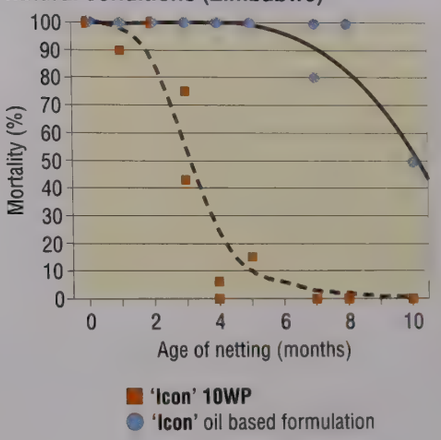



**Fig. 25. Monthly densities of *G.f.fuscipes* in areas treated with 'Icon' 10WP compared with untreated areas (Uganda)**

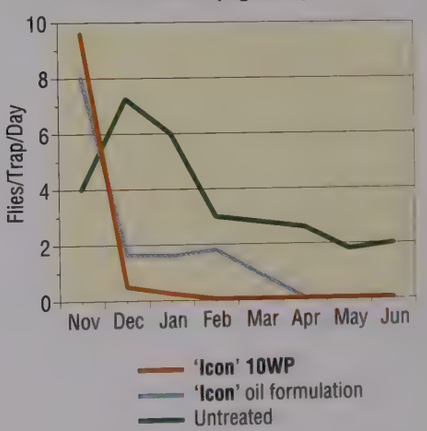
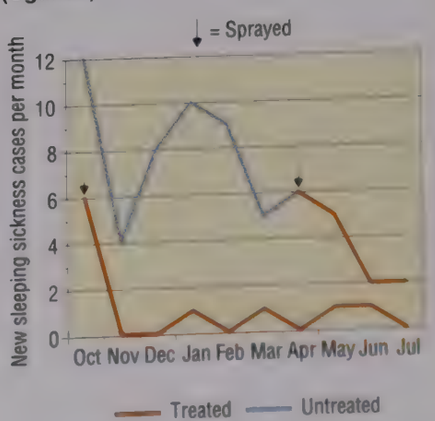



**Fig. 26. Monthly incidence of human sleeping sickness cases from 'Icon' treated areas compared with partially untreated areas (Uganda)***




* *Poyem Parish treated in November 1988 and with a partial second round in April 1989. Magola Parish untreated until 'Icon' sprayed in April-June 1989.*

# 9 Other pest species

## 9.1 FLEAS

In tests against the cat flea, *Ctenocephalides felis,* commercial formulations were diluted in distilled water and applied to filter papers. Fleas were confined on the treated papers for one hour and then transferred to clean recovery dishes. Mortality was assessed at 24 hours.

**Lethal dose (μgai/cm²) of pyrethroids to 50 or 90% of *Ctenocephalides felis* (UK)**

| Insecticide | $LC_{50}$ | $LC_{90}$ |
|---|---|---|
| [illegible] | [illegible] | [illegible] |
| permethrin | 173 | 558 |
| cypermethrin | 149 | >786 |

Tests with the same species were carried out in the USA using 'Icon' WP and 'Icon' 10CS (microcapsules).

**Efficacy of 'Icon' 10WP and 'Icon' CS against the cat flea *(Ctenocephalides felis)* (USA)**

| Treatment | Rate (mg ai/m²) | No. of live fleas | | | | | |
|---|---|---|---|---|---|---|---|
| | | Pre-treatment | 1 DAT | 3 DAT | 1 WAT | 2 WAT | 4 WAT |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| chlorpyrifos | 229 | 17 | 1 | 0 | 0 | 0 | 0 |
| control | 0 | 11 | 14 | 16 | 9 | 9 | 12 |

Both 'Icon' products gave quick knockdown and excellent control after 24 hours in a field trial (dog pen and adjacent lawn area). (Morris,1992).

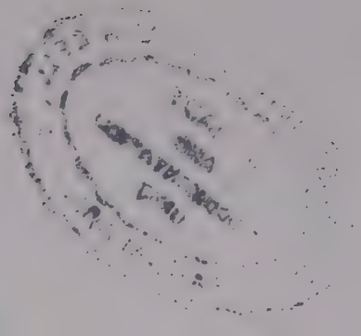
## 9.2 SCORPIONS

**Efficacy of 'Icon' 10WP against scorpions (USA)**

| Treatment | Rate % | % kill (2 hours) * |
|---|---|---|
| [illegible] | [illegible] | [illegible] |
| control | 0 | 0 |

* Scorpions held on glass panels for 2 hours.

'Icon' was effective against difficult to control scorpions. (Texas A&M University,1989).



**9.3 CRICKETS** – house cricket *Acheta domesticus*

**Efficacy of 'Icon' against the house cricket *(Acheta domesticus).***
**Substrate: unpainted plywood panels (USA)**

| Treatment* | Rates | Percent control: | | | | |
|---|---|---|---|---|---|---|
| | % ai | Days/Weeks after treatment (DAT/WAT) | | | | |
| | | 1DAT | 1WAT | 2WAT | 4WAT | 7WAT |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| chlorpyrifos | 0.05 | 20 | 23 | 33 | 16 | 10 |
| untreated control | 0.00 | 0 | 0 | 0 | 0 | 0 |

* Crickets exposed to treated panels for 30 seconds and then removed to clean beakers.

Mortality assessments one day and one to seven weeks after treatment showed that 'Icon' gave significantly better control than chlorpyrifos. 'Icon' at 0.06% ai gives excellent control for 7 weeks.

**9.4 SPIDERS** – Brown Recluse *(Loxosceles reclusa)*

**Residual surface test: 'Icon' and other insecticides on Brown Recluse Spider *(Loxosceles reclusa)* (USA)**

| Treatment* | Rates | Percent control: | | |
|---|---|---|---|---|
| | % ai | Days after treatment (DAT) | | |
| | | 1DAT | 7DAT | 14DAT |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| chlorpyrifos | 0.5 | 90 | 50 | 0 |
| bendiocarb | 0.5 | 0 | 0 | 0 |
| control | 0 | 0 | 0 | 0 |

* Plywood panels allowed to dry for 24 hours after treatment before spiders placed on treated surface for 48 hours before mortality assessment.

'Icon' at 0.05% was superior to all other treatments tested.

**9.5 OTHER SPECIES**

'Icon' has given very good control of a wide range of other species. Data is available on:

Ants – red imported fire ants *(Solenopsis invicta)*
– Coastal brown ant *(Pheidole megacephala)*
– Carpenter ants *(Campanotus* spp.*)*

Bugs – Boxelder bugs *(Boisea trivittata)*

Cockroaches – Brown banded *(Supella longipalpa)*
– Oriental *(Blatta orientalis)*

Firebrats – Firebrats *(Thermobia domestica)*

Ticks – Brown Dog Tick *(Rhipicephalus sanguineus)*
– Lone Star Tick *(Ambylomma americanum)*

Wasps – Mud daubers (Family *Sphecidae)*
– Digger or Scolid wasps (Family *Scolidae)*
– Yellow jackets and Hornets (Family *Vespidae)*

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# Toxicology

## 10.1 Laboratory Studies

The toxicology of lambda-cyhalothrin, the active ingredient of 'Icon', has been extensively studied to the standards required by WHO (1990a,1990b) and national regulatory authorities.

The studies show that 'Icon' may be used safely following the label recommendations for public health pest control. There have been no reports of any serious health effects in operators using 'Icon' in either field trials or large scale commercial use. The data from laboratory studies and field experience is summarised below:

**Acute oral and dermal $LD_{50}$ values for the rat**

| Formulation | | 'Icon' Technical | EC | WP | CS |
|---|---|---|---|---|---|
| | Conc. / Sex | 850g ai/kg | 25g ai/l | 100g ai/kg | 100g ai/l |
| **Acute Oral** | | | | | |
| mg/kg product | M+F | – | 923-1930 | 630 | >5000 |
| mg/kg ai | M | 79* | – | – | – |
| mg/kg ai | F | 56* | – | – | – |
| **Acute Dermal** | | | | | |
| mg/kg product | M+F | – | >1780 | >2000 | >2000 |
| mg/kg ai | M | 632# | – | – | – |
| mg/kg ai | F | 696# | – | – | – |

* in corn oil
# in propylene glycol

**Inhalation toxicity:** The 4-hour $LC_{50}$ to the rat of inspirable droplets generated from an EC formulation is approximately 41 mg ai/$m^3$ (male) and 23 mg ai/$m^3$ (female).

**Irritation:** Lambda-cyhalothrin is a mild eye irritant but is not a skin irritant.

**No effect level:** In a 90 day feeding study in rats, the toxicological no effect level was 50 ppm in the diet.

**Other studies:** From a range of in-vitro and in-vivo studies, it has been established that lambda-cyhalothrin is not mutagenic. Long term studies have shown that it is not a carcinogen. It has no effect on the reproductive system and is not teratogenic. It is rapidly excreted and does not accumulate in the body.

## 10.2 Field Experience:

There have been no reports of any serious health effects in operators using 'Icon'. As is the case with certain other ∝-cyano pyrethroids, including cypermethrin, deltamethrin, cyfluthrin and fenvalerate, 'Icon' can cause a tingling, burning or numbing sensation when it comes into contact with the skin, usually affecting the face.

The effects of 'Icon' are similar to those of other members of this group. The sensation is not related to classical irritation or other skin effects. The symptoms usually appear soon after exposure and last for no more than a few hours. Few incidents of this sensation have been reported from spray-men using 'Icon'. No serious consequences have arisen and no longer lasting effects were evident.

On occasions, during indoor application of 'Icon', spray-men have experienced irritation in the nose or throat which may give rise to coughing and sneezing. The symptoms soon disappear once the operator moves out of the area being sprayed and into fresh air. Again no longer lasting effects have been evident from this type of exposure. It seems that due to the solvents, the use of an emulsifiable concentrate (EC) is more likely to cause this effect than a wettable powder formulation (WP) or microcapsule (CS) formulation.

## SAFETY EVALUATION UNDER THE WHOPES SCHEME

### Pakistan

As part of the evaluation of 'Icon' 10WP for malaria vector control by the WHO Pesticide Evaluation Scheme (WHOPES), a human occupational exposure and health assessment was carried out during a field application by spray-men of the Malaria Control Programme in Pakistan in July 1988 (Chester *et al.*,1990, 1992). The Scheme requires that the candidate insecticide be evaluated for possible adverse effects on the health of workers associated with its use under realistic field conditions and on the health of the villagers whose homes are being sprayed (WHO, 1990a).

Skin sensory effects and occasional coughing and sneezing in confined spaces were the only symptoms resulting from the handling and spraying 'Icon' noted by workers. These effects have no medical significance and are regarded only as nuisance effects.

The compound was only poorly absorbed by the operators, under the typical conditions of a malaria control programme, as measured by the presence of metabolites in urine and serum. Only a small proportion of the villagers showed detectable metabolites in their urine and these were at, or close to, the limit of detection (Chester *et al.*,1990, 1992).

There is an occasional nuisance of skin sensory effects to some workers, which in itself has no medical significance. There should be no risk to the health of workers or to the people whose homes are treated with 'Icon', provided the normal care required for the use of all chemicals is observed, and the specific recommendations, given above, are followed.

### Tanzania

During the WHOPES Phase 3 trial of 'Icon' against malaria transmission in Tanzania, all except one of the twelve spray-men experienced skin sensory effects on the face, described as itching or burning, after exposure to 'Icon'. Respiratory irritation was prevented by the use of masks (Moretto,1991). Despite these symptoms, which were always transient and reversible, the spray-men all continued working willingly and soon learned to avoid personal exposure to these side-effects.

Inhabitants of the sprayed houses, when interviewed by Moretto (1991), on day 1 and days 5-6 after spraying, did not complain of any adverse effects when they reoccupied their houses after 'Icon' had been sprayed.

# Environmental Studies

The effects of 'Icon' on the environment have been studied in great depth. (ICI Agrochemicals,UK, 1988).

**Soil:**

Lambda-cyhalothrin is readily degraded in most soils and the products of degradation are ultimately converted to carbon dioxide and other benign metabolites. It does not leach through the soil as it is strongly adsorbed onto soil organic matter and is almost insoluble in water.

Lambda-cyhalothrin has no harmful effects on earthworms, soil micro-organisms or soil processes such as respiration, organic matter decomposition or nitrification at the application rates used in public health insect control.

**Water:**

Although lambda-cyhalothrin can be shown to be toxic to fish and some aquatic invertebrate organisms under laboratory conditions, it presents little hazard to aquatic life under actual field conditions due to the very low rates at which it is applied, its rapid adsorption on to suspended soil particles and its subsequent breakdown.

If any highly sensitive aquatic species, such as certain invertebrates are affected, the population effects are likely to be minor and temporary.

**Crop Residues:**

Application of 'Icon' for the control of vector and nuisance pests is unlikely to lead to the contamination of crops or livestock. In agricultural use the residues found on crops at harvest have been found to be negligible. This is due to the low rates required for insecticidal control and also to the degradation which occurs on plant surfaces. As a consequence, lambda-cyhalothrin formulations are widely registered for application to food crops.

**Impact on Wildlife:**

Lambda-cyhalothrin has very low toxicity to birds.

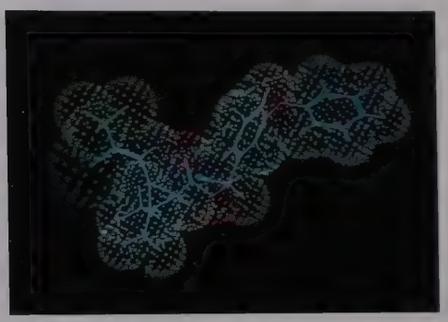
Although in laboratory tests it is toxic to bees, it has been tested at rates of up to 15 grams ai/ha in the field i.e 15 times higher than the rate used in public health, without causing harmful effects. An additional safety factor is that public health applications, whether from the ground or the air, are made in the early morning or early evening when bees are not active on crops, even in full bloom.

In agricultural tests, any effects of lambda-cyhalothrin on populations of insect predators and parasites have been shown to be short lived. In public health use the hazard to non-target species is negligible (ICI Agrochemicals,1988).

# Chemical and Physical Properties of Technical Material

- Common name : Lambda-cyhalothrin
- Chemical Name : ∝-cyano-3-phenoxybenzyl 3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2, 2-dimethylcyclopropane carboxylate, a 1:1 mixture of the (Z)-(1*R*, 3*R*), S-ester and (Z), (1S, 3S), R-ester.
- Code Names : PP 321, OMS 3021, ICI A 0321
- Molecular Formula : $C_{23}H_{19}ClF_3NO_3$
- Molecular Weight : 449.9
- Solubility : $5x10^{-3}$ mg/l (purified water). $4x10^{-3}$ mg/l (buffered water). Soluble in a range of common solvents at 21°C
- Melting point : 49.2°C
- Physical state : Solid when pure
- Appearance : White (pure), Beige (technical grade)
- Odour : No characteristic odour
- Vapour pressure : $2 \times 10^{-10}$ kPa at 20°C
- Stability : Stable at 15-25°C for >6 months as technical product. Formulated material is stable for at least 2 years under normal storage conditions.
- Analysis : Can be analyzed using standard techniques. An analytical method is available from Zeneca Public Health on request.

**Lambda-cyhalothrin: Structural formula and enantiomer (1:1 mixture)**



- WHO Interim Specifications – Reference Number:VBC/1S/91.23 (WHO,1991).
- Technical Lambda-cyhalothrin WHO/1S/1.3021-1
- Lambda-cyhalothrin Water-Dispersible Powder WHO/1S/2.3021-1
- Lambda-cyhalothrin Emulsifiable Concentrate WHO/1S/3.3021-1
- IPCS International Programme on Chemical Safety, Environmental Health Criteria No.99: Cyhalothrin (WHO,1990b).
- IPCS International Programme on Chemical Safety, Health and Safety Guide No.38: Cyhalothrin and Lambda-cyhalothrin (WHO,1990c).

# Formulations and Standard Recommended Rates of Application

**FORMULATIONS**

There is a suitable formulation of 'Icon' available for every possible public health use.

| Formulation | Lambda-cyhalothrin content: g ai/l or kg | Dilute with: |
|---|---|---|
| EMULSIFIABLE CONCENTRATES: | For general purpose spraying (including hot fogging and ultra low volume) | |
| [illegible] | [illegible] | [illegible] |
| WETTABLE POWDER: | For residual spraying | |
| [illegible] | [illegible] | [illegible] |
| FOGS: | For use with hot fogging machines | |
| [illegible] | [illegible] | } [illegible] |
| ULV: | For very low volume application using a cold fog aerosol machine | |
| [illegible] | [illegible] | } [illegible] |
| MICROCAPSULES: | For residual use, particularly on porous surfaces or under outdoor conditions and on fabrics | |
| [illegible] | [illegible] | } [illegible] |

**Storage Stability**

These formulations are stable for at least two years, when stored in unopened sales containers, under normal storage conditions and protected from extremes of temperature i.e direct sunlight and freezing.

## STANDARD RECOMMENDED RATES OF APPLICATION

| Treatment | | Formulation | Diluent | 'Icon' rate (mg ai/m²) | Volume (ml/m²) |
|---|---|---|---|---|---|
| **Residual** | | | | | Wet surface |
| Exterior | nuisance insects | 10WP | Water | 20 | 30 |
| | | 10CS | | 20 | 40 |
| | | 2.5EC | | 30 | 40 |
| Interior | nuisance insects | 10WP | Water | 10 | 30 |
| | | 10CS | | 10-20 | 40 |
| | | 2.5EC | | 20 | 40 |
| Interior | malaria vectors | 10WP | Water | 30 | 30 |
| **Fabric** Mosquito netting | Cotton, Nylon | 2.5CS | Water | 10 | Thoroughly soak nets in dilute lambda-cyhalothrin: 0.025% for cotton, 0.05% for nylon and other synthetic fabrics. Air dry on a shaded, flat non-absorbent surface. |
| **Larvicide** | | | | | |
| | Housefly | 2.5EC | Water | 12.5 | 100 |
| | Mosquito/ Polluted water | 2.5EC | Water | 1.0 | 10 |
| | | | **Diluent** | **'Icon' rate (g ai/ha)** | **Volume (l/ha)** |
| **Space** | | | | | |
| Thermal Fog | Hand-held | 2.5 Fog | Kerosene or Diesel | 1.0-2.0 | 2 |
| | | 0.6 Fog | | | |
| | | Extra Fog | | 1.5-2.0 | |
| | | Ultra Fog | | | |
| | Vehicle-mounted | 2.5 Fog | Kerosene or Diesel | 2.0 | 5 |
| | | 0.6 Fog | | | |
| | | Extra Fog | | 1.5-2.0 | |
| | | Ultra Fog | | | |
| Cold Aerosol ULV | Hand-held or Vehicle-mounted | 2.5 ULV | Kerosene or Diesel oil | 1.0 | 0.5 |
| | | 0.6 ULV | | 1.0-1.5 | |
| | | Extra ULV | Diesel only | 0.5-1.0 | |
| | | Ultra ULV | | | |

**Application rates may vary depending on local conditions.**

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# Notes

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